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Planning and Designing of Rural Water Supply System

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Abstract— Water is the basic need of human being as well as entire live species in the environment. As we know water occupied a major part in the body of human being. Therefore water plays important role in maintaining the health of human being that can be ensured by providing sufficient, regular and safe water to every house in rural as well as in urban area by means of providing water supply system. The government of Gujarat is also ensuring to provide regular, enough and safe water to the rural & urban community. Water supply system includes water sources, water storage at the location; water distribution network and Underground sump along with pumping mainline with a suitable pump.
Sartanpar village is selected as study area. In village Sartanpar which is located in Jasdan taluka of Rajkot district. Sartanpar village population is 889 souls as per census 2011 and present population is 965 as in the year 2016. The project period is considered 30 years, therefore, the population is forecasted using the arithmetic Increase method. Existing water supply system is cluster water distribution system. Propose an alternate solution for water distribution system is based on elevated storage reservoir with staging height 12mt. Water distribution network is designed by loop 4 software.

Keywords— Water Supply System, Loop 4, Rural Area, Optimization of WDN, cost estimation

I. INTRODUCTION

Water supply has been a primary logistical challenge since the dawn of civilization. Water resources are insufficient for the population; people survive against disease, dehydration, or in cases like death. The growth of population directly affected the water distribution system. And if a surface water source was not available, there are other sources like shallow wells to supply water to community residents [3]. Water demand is increasing day by day whether it is domestic, industrial and agricultural etc., but the source of water is limited. So, authorities around the world are faced with the problem to provide sufficient water from the limited water source. Due to human consumption, water distribution system directly influences the development of the area as well as the nation. Water distribution network plays important role in providing desirable life quality to the public, which the main component is the reliability of supply. To solve this problem, it is necessary to upgrade distribution system [2].

Water distribution network problems deal with design and analysis. Engineering design is the synthesis of theory and precedent. The design problem is to determine the sizes of system components. Conventional procedures for design and analysis are iterative trial and error. The effectiveness of conventional procedures is dependent upon an engineer's intuition, experience, skill and knowledge of the system. The traditional method for designing pipe network is by trial and error guided by experience. Therefore, conventional procedures are highly related to the human element, which could lead to inefficient design. The analysis is concerned with determining the behavior of an existing system or a new system being designed. In many cases, the study of the system behavior is to determine the operation of the system or the response of the system under specified inputs. In other words, a design is formulated and followed by an analysis to see if it performs according to specifications, hydraulic conditions, demands, costs of components, laying the system pipe links and operating the same are to be considered in developing models for water distribution network. The unit's prices of pipes are not only a function of diameter, but also a function of such parameter as the location in the system.

II. STUDY AREA AND DATA COLLECTION

Sartanpar village is located in Jasdan Taluka of Rajkot district in Gujarat, India. It is situated 34km away from sub-district headquarter Jasdan and 92km away from district headquarter Rajkot. Sartanpar gram panchayat is acting as a governor body. The total geographical area of the village is 699.59 hectares. Sartanpar has a total population of 889 souls as per the 2011 year Census. There are about 151 houses in Sartanpar village. Botad is the nearest town to Sartanpar which is approximately 26km away. Location of sartanpar is shown in fig.1.

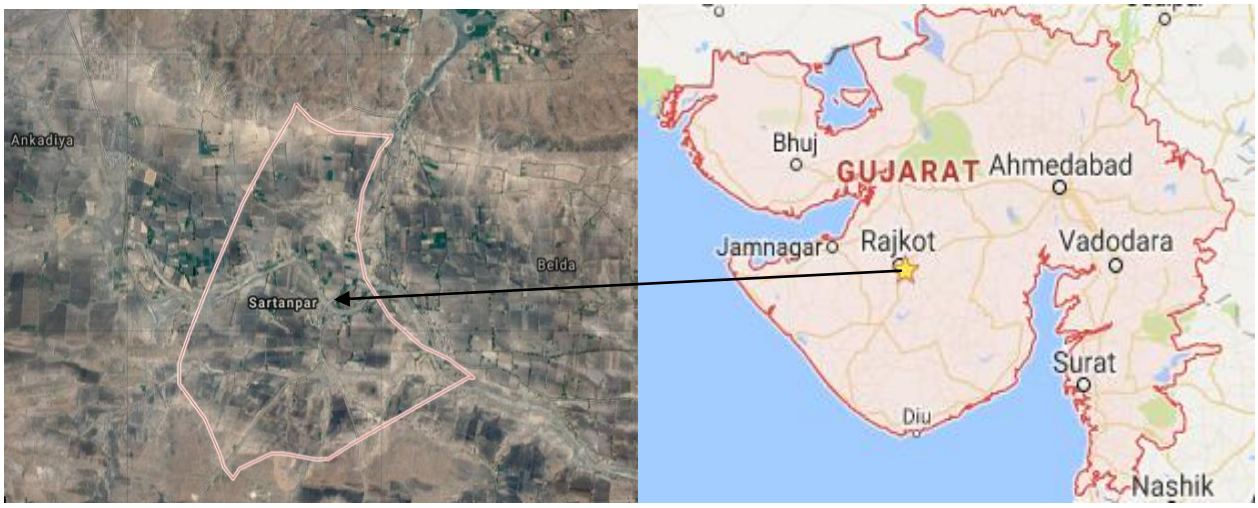

Fig. 1 Location map of Sartanpar village

In Village, the Cluster water distribution system is found. The entire village area is divided into different four zones and Water is distributed from Cistern in each zone. Existing bore 8" and 300' deep and Narmada pipe line are available as water sources for the village. Topographical, water sources, water storage data of Village is collected from Water and Sanitation Management organization (WASMO). Water distribution network map is prepared in AutoCAD software which is shown in fig:2. In the fig.2, details of node number, the Ground level of the node, pipe length, the location of proposing elevated storage reservoir is given. Pipe cost is collected from vender of PVC pipe as on the year 2016.

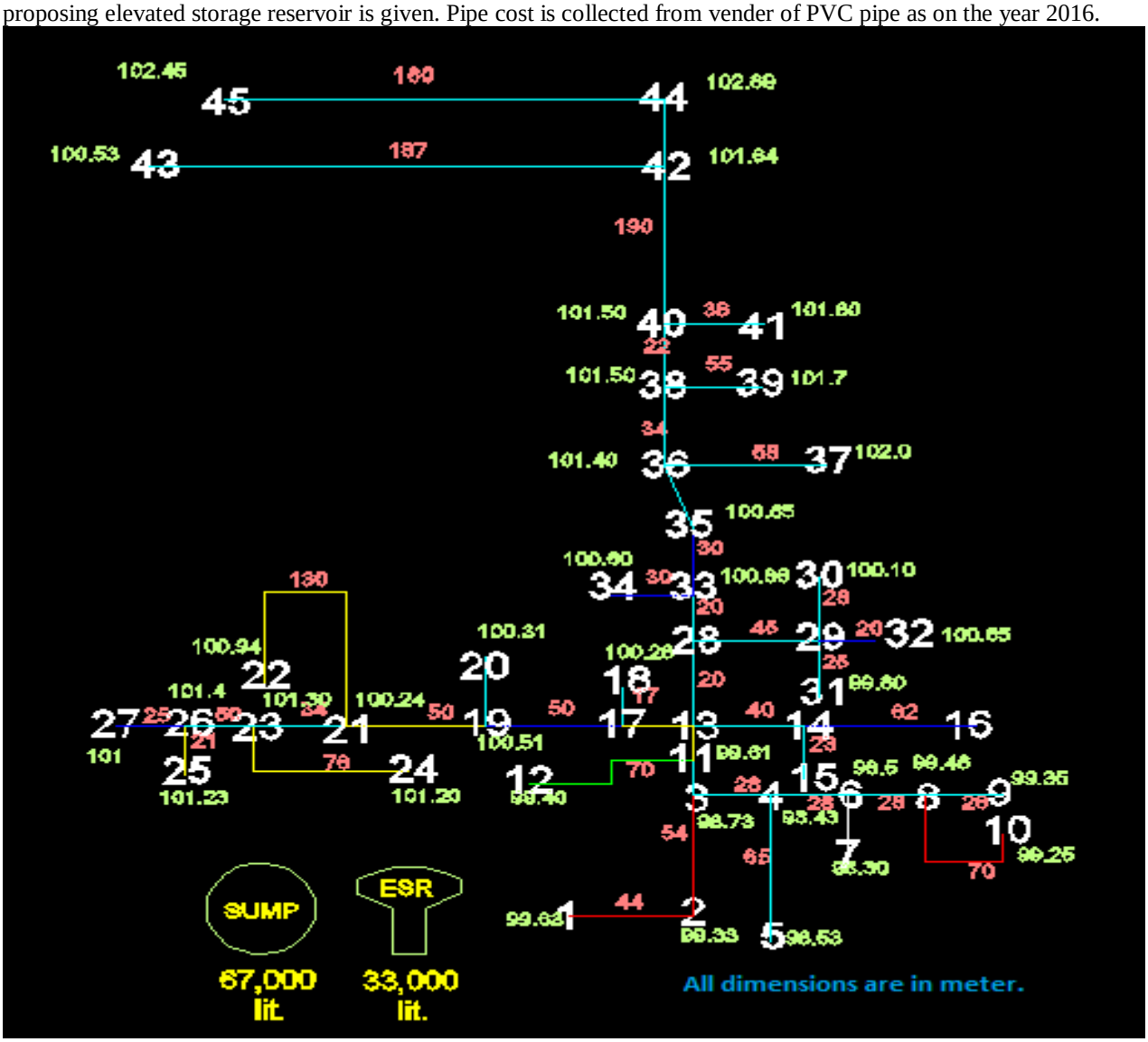

Figure 2 Proposed water distribution Network

III. METHODOLOGY

Our basic aim of this study is to provide safe, regular and enough water to rural areas through water supply system so they can get potable water easily. And provided water is good in quality and sufficient quantity is equally important. The second aim of this study is to be providing an alternate solution for water distribution in the study area. The methodology is adopted for this study is described step by step in this section:

A. Population forecasting

According to water supply manual, standard design period of water supply project is considered 30 years. Therefore Population forecasting is done for next 30 years plan. There are some different methods for population forecasting out of that geometric growth average method is used to a new city with rapid growth and arithmetic methods is used for less developed with less population area such as rural area. Population forecasting of the village is presented in Table 1 for sartanpar Village.

Table 1 Population Fo6ecast for Sartanpar village

2011 (Census year)	2016 (Present population)	2031 (Intermediate population)	2046 (Ultimate stage year)
889	965	1207	1448

B. Total daily water Demand

Daily water demand is worked out for sartanpar village water supply scheme is work out for the present, intermediate and Ultimate stage of the project. The rural domestic need of drinking water is considered 70 liters per capita per day (lpcd) according to recommends in manual of water supply and treatment, prepared by the ministry of Urban Development, New Delhi.

C. Water storage capacity

Water storage structure capacity is calculated at ultimate stage of the project according to government suggested rules for the rural area. Therefore proposed underground sump capacity is considered 67000liters and Elevated storage Reservoir capacity is considered 33000liters with 12 mt staging.

D. Loop Software

BRACH & LOOP Software was developed by Dr. Prasad Modak and Juzer in 1990 with support of World Bank for optimization of looped water distribution network. With LOOP software, Design & simulation can be done for water distribution network.

Loop software is a computer-aided planning and design of low-cost water supply and waste water disposal systems in developing countries. In this software, Newton –Raphson technique and the Hazen-Williams or Darcy –Weisbach flow Equations are used for the heuristic design of looped distribution networks. Loop version4.0 handles up to 1000 pipes and 750 nodes as well as multiple sources with fixed or variable heads, fixed or unknown flows, booster pumps, check valves and pressure regulating valves. This program also shows hydraulic grade lines along chosen section and calculates head losses, velocities; Valve operating status, pumping heads etc and cost. The program has been designed for easy entry, editing, and updating of data. It is provided in complied quick BASIC form to speed program execution.

E. Input Data considered while using LOOP Software.

- Geometric Data: Node pipe connectivity, length of all pipes, ground levels of all nodes etc are shown in fig.2
- Hydraulic data: Average water Demands at all the relevant nodes, Pipe resistance coefficient in terms of Hazen William's C or pipe roughness coefficient k in Darcy-Weisbach expression. For PVC pipe C value is considered 140.
- Source data: Elevated storage reservoir level is 111.83mt
- Cost estimation Parameters: Available commercial diameters of PVC Pipe are considered with data on unit cost and working pressure, Newton-Raphson stopping criterion (0.001), Maximum (60m) and minimum (7m) pressure at nodes. Design Hydraulic gradient is 1.5m per 1km.
- Population per node find by calculating house hold x family member
- Water demand for each node = Population of node x water demand (70 lpcd)

- Outer Diameter of pipes are taken in a range of 75mm to 200mm, its respective inner diameter is 69.3mm to 185.5mm.
- Peak factor 3 has been considered as per manual of water supply & treatment, Ministry of Urban Development, New Delhi.
- By using above data input file is prepared for water distribution network design using LOOP Software and the input file is run in the software.

F. Pumping Machinery is design for water demand at intermediate stage of project which is calculated by intermediate stage population X 70lpcd. Life period of pumping Machinery is considered 15 year as per manual of water supply and treatment.

IV. RESULT

Result obtained from the design of Water distribution network using Loop Software is presented in tabular form as per below:

Table 2 Summary of pipe output from LOOP Software

Pipe No.	Optimize inner diameter of PVC pipe in mm.	Length in m	Cost of pipe per unit length	Estimated Cost of pipe in Rs.
1,2,10	129.7	109	293	31937=00
3,4,5,6,7,8,9,11,14,15,18,20,21,26,28,29,30,31,33,36,37, 38,39, 40,41,42,43,44,45	69.3	1844	87	160428=00
12	102	30	179	5370=00
16,17,27,32,34,35	83.2	399	124	49476=00
13,19,22,23,24,25	185.5	212	415	87980=00
The total Estimated cost of Pipe in Rs.				335191=00

V. CONCLUSIONS

The conclusion is derived from the entire study and optimum design of water distribution network using Loop software as per following

- Minimum outer diameter suggested by software is 75mm and maximum outer diameter is suggested 200mm.
- Node minimum residual pressure is observed 8.43m and Node maximum residual pressure is observed 13.39m.
- Water distribution network estimated cost is 3, 35,191=00.
- Existing UG sump 1, 00,000 capacity is utilized as underground storage.
- Propose Elevated Storage Reservoir 33000 liters capacity with 12 mt staging.
- Proposed Pumping Machinery at UG SUMP is 2HP, 180 LPM, for 8 hours pumping.

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